# Caddisflies (Trichoptera) of Ohio Wetlands as Indicated by Light-Trapping[1, 2]

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ABSTRACT. The caddisfly fauna of 14 Ohio remnant bogs and fens was sampled by means of light traps operated from May to October in 1984 and 1985. A total of 37,061 adult Trichoptera representing 13 families, 43 genera, and 135 species resulted from 123 collections. New state records are reported for *Glossosoma intermedium* Banks, *Goera calcarata* Banks, *Lepidostoma costale* (Banks), *Limnephilus hyalinus* Hagen, and *Oecetis ochraceae* (Curtis). Detrended correspondence analysis of the 100 most abundant species revealed significant correlations between the ordination axis scores and latitude, longitude, caddisfly species richness, and diversity. Documentation of the Trichoptera of these bogs and fens may provide important baseline data for the evaluation of future environmental changes and the management of Ohio's wetlands.

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## INTRODUCTION

Since the creation of the Ohio State Nature Preserve System in 1970, over 5,868 ha of Ohio's natural areas have been preserved (J. Williams, Ohio Division of Natural Resources, pers. comm.). Acquisitions under this program include some of the finest or the only known examples of specific habitat types within the state, such as Goll Woods, Fulton County (oak-savannah); Schwamberger Prairie, Fairfield County (tall grass prairie); Old Woman's Creek, Erie County (freshwater estuary); Headland Dunes, Lake County (dune community); Prairie Road Fen, Clark County (minerotrophic fen); and Brown's Lake Bog, Wayne County (weakly ombrotrophic bog).

Many Ohio preserves exist solely because of the occurrence of threatened or endangered plant species (Andreas 1982, Cooperrider 1982, McCance and Burns 1984, Platt 1985). Bogs and fens often provide suitable habitat for species of plants and insects uncommon in Ohio (Stein 1974). The elimination of potential competitors owing to extremes in pH and nutrient deficiencies enables some boreal plant species to exist in Ohio bogs. Wetlands, which were formed following the retreat of the Wisconsinan Glacier 10,000-20,000 years B.P., are associated with esker-kame complexes (Stuckey and Denny 1981) and buried river valleys of the Teays River system (Andreas 1985). Pollen cores indicate that interlobate areas in Portage County, as well as southern Ohio wetlands in Clark County, have been ice-free for approximately 19,000-20,000 years (Shane 1974). Many bogs and fens, which covered less than 1% of the land surface of Ohio in 1912 (Dachnowski 1912), have since been destroyed (Stuckey and Denny 1981).

Although protected by the Ohio Natural Areas Act of 1970, the integrity of these fragile areas may be threatened by the development of adjacent land, air pollution, and urban encroachment (Elfring 1986). Urbanization, mineral extraction, and agriculture are largely responsible for the fragmentation and isolation of these wetlands (Marrs et al. 1986). In addition to the destruction of many wetlands by human activities, natural succession alters these areas considerably (Aldrich 1937).

Measures have been taken to preserve the integrity of these habitats through restricted use and selective re-

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moval of unwanted vegetation (J. Young, The Nature Conservancy, pers. comm.). Previous chemical and floristic studies have provided much of the information used for the preservation and management of wetlands (Andreas 1985, Heinselman 1970, McKnight et al. 1985, Schwintzer and Tomberlin 1982, Stuckey and Denny 1981, Tyrrell 1985). Although it has been reported that "wetland biological communities contain many of the rarest and most interesting plant and animal species native to the Great Lakes Region" (Shuey 1985), few studies have considered the fauna of these glacial remnants (Utter 1971).

Caddisflies were chosen for study because they are usually more numerous and diverse than other aquatic insect orders (Wiggins 1977). Previous work (MacLean and MacLean 1984, Usis and MacLean 1986) has also shown that Trichoptera are well represented in Ohio wetlands. The order Trichoptera is represented in North America by more than 1,200 species in approximately 145 genera and 21 families (Wiggins 1984). The addition of five new state records brings the total number of caddisflies reported for Ohio to 213 species (Huryn and Foote 1983, Usis and MacLean 1986). In aquatic communities, caddisflies have a wide range of habitats and trophic levels, and are exceeded only by Diptera in number of species and genera (Wiggins and Mackay 1978). All families of caddisflies are represented in cool, fast-flowing streams; many taxa have secondarily adapted to slow-moving, poorly oxygenated bodies of water (Wiggins 1977). Ross (1956) reported that the three most primitive families of caddisflies, the Philopotamidae, Rhyacophilidae, and Glossosomatidae, live in cool streams with temperatures of 7 to 13°C. Mackay and Wiggins (1979) reported that many species of Limnephilidae, Leptoceridae, Phrygenaidae, Molannidae, Hydroptilidae, and Polycentropodidae tolerate the reduced dissolved oxygen concentration of large, slow-moving bodies of water. This adaptive radiation into both lotic and lentic habitats coupled with the successful exploitation of available energy in aquatic systems has been attributed to the ability of caddisfly larvae to spin silk (Mackay and Wiggins 1979).

During this 2-year study, initiated in the spring of 1984, the caddisfly fauna was surveyed in 14 remnant Ohio wetlands. Glacially formed, these wetlands exhibit many differences in plant communities, topography, pH, and conductivity. The objective of this study was to provide baseline data on the distribution of the Trichoptera fauna of Ohio's remnant bogs and fens, which can be used to monitor the effects of future environmental changes and to manage these natural areas.

## DESCRIPTION OF STUDY AREAS

Bog and fen sites included in this study all occur within glaciated Ohio (Fig. 1) and are managed by either the Ohio Department of Natural Resources (ODNR) or The Nature Conservancy (TNC) (Table 1). Bogs and fens were differentiated using the criteria provided by Andreas (1985). A sphagnous bog is characterized by standing water of pH 3.5 to 5.5 with little or no circulation; a well developed mat dominated by *Sphagnum* in the ground layer; and shrubby vegetation dominated primarily by species of Ericaceae and herbaceous vegetation by species of Cyperaceae. Fens are


FIGURE 1. Map of Ohio showing the locations of the 14 remnant Ohio bogs and fens and the maximum Wisconsinan glaciation.

TABLE 1.

*Site, county, area (ha), elevation (m), and managing agency (TNC, The Nature Conservancy; ODNR, Ohio Department of Natural Resources).*

| Site | County | Area (ha) | Elevation (m) | Managing agency |
|---|---|---|---|---|
| Betsch Fen | Ross | 14.2 | 221.0 | TNC |
| Brown's Lake Bog | Wayne | 32.4 | 292.6 | TNC |
| Cranberry Bog | Licking | 7.9 | 274.3 | ODNR |
| Eagle Creek Bog | Portage | 178.6 | 289.6 | ODNR |
| Frame Lake Fen | Portage | 50.6 | 320.0 | TNC |
| Gott Fen | Portage | 5.5 | 320.0 | ODNR |
| Jackson Fen | Stark | 6.5 | 320.0 | ODNR |
| Kent Bog | Portage | 17.0 | 341.4 | ODNR |
| Kiser Lake Fen | Champaign | 20.6 | 336.8 | ODNR |
| Lake Kelso Bog | Geauga | 18.9 | 340.8 | TNC |
| Liberty Fen | Logan | 3.6 | 333.8 | ODNR |
| Lone Larch Bog | Stark | 282.0 | 320.0 | ODNR |
| Prairie Road Fen | Clark | 38.5 | 320.0 | ODNR |
| Triangle Lake Bog | Portage | 24.8 | 344.4 | ODNR |

characterized by water of pH 5.5 to 8.0, which originates from springs and seeps; a wet calcareous substrate that supports minerotrophic species of *Sphagnum* and other bryophytes that do not form a continuous mat; and vegetation dominated by species of Cyperaceae, Compositae, Rosacacae, and Gramineae, with approximately 20% of the vegetation dominated by shrubs.

NORTHEASTERN OHIO. The largest number (9) of sites studied occurred within northeastern Ohio. Lake Kelso Bog, located in central Geauga County (T7N, R7W), is one of several kettle hole lakes of the Cuyahoga Wetlands. This bog essentially lacks a floating *Sphagnum* mat. The shoreline vegetation is composed primarily of loosestrife, *Decodon verticillatus* (L.) Ell. The northwest shore of this 16.2-ha preserve contains a remnant white pine-bog community with many large *Pinus strobus* L. (ca. 15 m high). The site was acquired by TNC in 1984.

Eagle Creek Bog, a 178.6-ha state nature preserve located in Portage County, Ohio (T5N, R6W), supports a variety of different plant communities including oak woodlands, old field, marshes, and buttonbush swamps. A natural bog community located in the northeast corner of the preserve consists of an open *Sphagnum* mat and mat covered mostly with *Acer rubrum* L. The site was dedicated as an interpretive nature preserve in 1974.

Frame Lake Fen, also known as Herrick Fen and Seasons Road Bog, is located on the Glaciated Allegheny Plateau in northeast Portage County (T4N, R9W). Exhibiting characteristics of both fens and bogs, this 50.6-ha preserve supports a mosiac of bog meadows and tamarack forests (*Larix laricina* (Du Roi)) on the northeast shore. Large trees in this mixed-aged stand are estimated to be 15 to 25 m in height. The preserve area is surrounded by old fields, a mature beech-maple stand, and a sand and gravel pit on the northeast shore. Several unusual northern species of sciomyzid flies were reported for the area (Stein 1974). The site was dedicated as an interpretive nature preserve on 14 April 1982.

Gott Fen, one of Ohio's finest examples of a boreal fen, is located in northeast Portage County (T4N R9W). This small site (5.5 ha) is surrounded by wetlands and is bordered by railroad tracks on the west and Tinker's Creek on the east.

Kent Bog is a 16.9-ha glacial remnant bog located in Portage County (T2N, R9W) within the esker-kame complex of the Kent end moraine. This bog is believed to contain one of the largest and southernmost stands of native tamarack in Ohio (1,500-2,000 native tamarack ranging in size from seedlings to 15-20-m high trees).

Triangle Lake Bog in northeast Portage County (T2N, R9W) is one of the best examples of a bog sere in Ohio. The 25-ha kettle lake bog exhibits a floating *Sphagnum* mat and an almost complete ring of tamarack.

Jackson Fen is located in northwestern Stark County (T11N, R9W), where the Killbuck Lobe of the Wisconsinan Glacier bordered the Grand River Lobe some 18,000 years B.P. This 6.5-ha preserve contains a 2.3-ha calcareous fen, one of only two in the state where the pitcher plant (*Sarracenia purpurea* L.) grows. This area, which is managed by the ODNR, was dedicated as an interpretive nature preserve in 1980.

Lone Larch Bog (0.6 ha) is located within Quail Hollow State Park, Stark County (T20N, R12W) and is managed by the ODNR. This mature bog contains only a few typical bog indicator plant species (e.g., tamarack and poison sumac, *Rhus vernix* (L.)). Woody vegetation covers much of the area which is entirely flooded in early spring and late fall. Early photographs (ca. 1930) show that the bog area at that time was partially drained. Later photographs show a stand of tamarack, remnants of which are visible today. The pitcher plant, leather leaf (*Chamaedaphne calyculata* (L.) Moench.) and cotton grass (*Eriophorum* sp.) were reintroduced to the area early in 1986.

Brown's Lake Bog, one of the state's better known kettle hole bogs, is located on the glaciated Allegheny Plateau of Wayne County (T18N, R14W) southwest of Wooster. This area, which was dedicated as a national landmark in 1968 and as a scientific state nature preserve in 1980, is owned and managed by TNC.

SOUTH-CENTRAL OHIO. Two sites were surveyed in south-central Ohio (Fig. 1). Located in central Licking County, Cranberry Island Bog (T19N, R12W) has a unique history and is a registered national landmark. Floating in alkaline Buckeye Lake, Cranberry Island was unintentionally created in 1830 when an area known as Big Swamp was flooded to furnish Ohio's canal system with water. A sphagnum area of Big Swamp expanded and rose to the surface of the newly formed reservoir. Approximately 8 ha of the original 20 ha habitat remains today, and was dedicated as a scientific preserve on 18 May 1973.

Betsch Fen is located on the till plains of north-central Ross County (T9N, R21W) near the terminal moraine of the Wisconsinan Glacier. This 14.2-ha preserve is completely surrounded by actively cultivated land and pastures.

WEST-CENTRAL OHIO. Three sites were studied in west-central Ohio (Fig. 1). Kiser Lake Fen, located in Champaign County (T4N, R12W), is one of the last remnants of Mosquito Lake Bog which was largely destroyed during the construction of Kiser Lake. This 20.5-ha fen is located within Kiser Lake State Park and is managed by the ODNR. Liberty Fen, a small (3.6 ha) preserve located on the till plains of Logan County (T5N, R13W) is surrounded by agricultural land. The area is owned and managed by the ODNR and was dedicated as a nature preserve in 1981. Located on the till plains of southeastern Clark County, Prairie Road Fen (T5N, R13W) is one of Ohio's largest fens (38.5 ha) and includes artesian springs, exposed marl, and prairie and boreal plant species.

## MATERIALS AND METHODS

A portable light trap was placed near the center of each site and operated overnight for approximately 6 to 8 h. The following light traps were used throughout the study: two Ellisco-type; one bioquip, Model 2851A; and two Carolina Biological, Model 65-4155. A total of 123 collections were made from May through October of 1984 and 1985. Whenever possible, traps were operated at two or more sites on the same collection night.

Light traps have been used extensively by various workers to survey caddisfly populations (Swegman et al. 1981, Usis and MacLean 1986). McElravy (1976) found that light trap collections included many species of Trichoptera sampled by larval collections and emergence traps. Although light trap collections are non-random samples and should be treated as populations (Pielou 1966), the operation of traps at several nearby sites on the same evening minimized the effects of temperature and wind on flight behavior (Fremling 1960, Usis and MacLean 1986). Air temperature of bogs and fens was generally 4-10°C cooler than adjacent habitats. Except for some of the larger-bodied Limnephilidae and Phryganeidae, flight activity ceased on evenings when temperatures dropped below 17°C.

Acidity and conductivity (corrected for 25°C) were measured (Hach Digital pH Meter, Model 19000; Fisher Conductivity Meter, Model 152) in the early spring of 1986. Three samples were taken at each site, two from shallow (15 cm) wells and one from surface water (Schwintzer 1977). Owing to an equipment malfunction, pH values were not recorded for Cranberry Island Bog, nor were conductivity values recorded for Gott Fen.

Brillouin's index,

$$H = \frac{1}{N} \log \frac{N!}{N_1!N_2!\ldots N_s!},$$

and $J = H/H_{max}$ were calculated (MacLean and MacLean 1984, Pielou 1966) with the collection data to determine species diversity ($H$) and evenness ($J$). Brillouin's index ($H$) expresses the uncertainty of correctly predicting the identity of an individual picked at random from a collection of size $N_i$; evenness ($J$) expresses the ratio of

species diversity to the maximum possible diversity for a collection of $S$ species of size $N$. Pielou (1966) recommended the use of Brillouin's index to analyze species diversity of light trap collections. A detrended correspondence analysis (Gauch and Whittaker 1972) was carried out for all sites based on the 100 most abundant Trichoptera species. Correspondence analysis or reciprocal averaging is superior to other principal component methods, since it performs both an R-type or site ordination and a Q-type or species ordination simultaneously (Gauch 1982, Pielou 1984).

## RESULTS

A total of 37,061 adult caddisflies representing 13 families, 43 genera, and 135 species were collected. Included in the 123 collections, which represented nearly 68% of the Trichoptera recorded for the entire state, were five new state records. Only those species present at four or more sites or represented by 10 or more specimens were recorded in Table 2. The new state records and their sites of collection (in parentheses) were: *Glossosoma intermedium* Banks (Liberty Fen), *Goera calcarata* Banks (Jackson Fen and Eagle Creek Bog), *Lepidostoma costale* (Banks) (Prairie Road Fen), *Limnephilus hyalinus* Hagen (Eagle Creek Bog), and *Oecetis ochraceae* (Curtis) (Brown's Lake Bog, Cranberry Bog, Frame Lake Fen, Liberty Fen, Lone Larch Bog, Prairie Road Fen, and Triangle Lake Bog). The following species were only tentatively identified on the basis of female specimens or poor male specimens: *Hydropsyche cuanis* Ross, *H. placoda* Ross, *Ochrotrichia eliaga* (Ross),

TABLE 2

*Numbers of adult Trichoptera collected in 1984 and 1985 from 14 Ohio remnant bogs and fen wetlands. 1, Betsch Fen; 2, Frame Lake Fen; 3, Gott Fen; 4, Jackson Fen; 5, Kiser Lake Fen; 6, Liberty Fen; 7, Prairie Road Fen; 8, Brown's Lake Bog; 9, Cranberry Island Lake Bog; 10, Eagle Creek Bog; 11, Kent Bog; 12, Lake Kelso Bog; 13, Lone Larch Bog; 14, Triangle Lake Bog.*

| | Fens | | | | | | | Bogs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Taxon | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Hydropsychidae | | | | | | | | | | | | | | |
| *Ceratopsyche* | | | | | | | | | | | | | | |
| *bronta* | 28 | 1 | 16 | 22 | 10 | 879 | 204 | 16 | 0 | 3 | 6 | 1 | 3 | 4 |
| *cheilonis* | 155 | 0 | 0 | 28 | 6 | 20 | 55 | 2 | 0 | 1 | 1 | 0 | 6 | 0 |
| *morosa* | 12 | 0 | 17 | 2 | 2 | 87 | 85 | 4 | 0 | 1 | 0 | 1 | 2 | 0 |
| *slossonae* | 0 | 2 | 30 | 21 | 8 | 669 | 73 | 26 | 0 | 18 | 7 | 2 | 4 | 3 |
| *sparna* | 0 | 0 | 1 | 25 | 1 | 325 | 81 | 0 | 0 | 12 | 1 | 3 | 2 | 1 |
| *Cheumatopsyche* | | | | | | | | | | | | | | |
| *aphanta* | 0 | 0 | 0 | 9 | 0 | 12 | 4 | 0 | 0 | 0 | 2 | 1 | 0 | 0 |
| *campyla* | 1,457 | 6 | 1 | 60 | 18 | 112 | 30 | 13 | 1 | 0 | 19 | 3 | 1 | 4 |
| *oxa* | 25 | 2 | 0 | 12 | 6 | 74 | 24 | 1 | 1 | 3 | 1 | 0 | 0 | 0 |
| *pettiti* | 37 | 11 | 13 | 5,610 | 8 | 59 | 23 | 28 | 3 | 10 | 42 | 29 | 13 | 81 |
| *Hydropsyche* | | | | | | | | | | | | | | |
| *betteni* | 27 | 4 | 29 | 666 | 8 | 26 | 18 | 8 | 0 | 2 | 2 | 17 | 5 | 1 |
| *bidens* | 0 | 0 | 0 | 0 | 8 | 8 | 7 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| *dicantha* | 0 | 0 | 1 | 2 | 3 | 5 | 6 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| *incommoda* | 0 | 0 | 0 | 0 | 4 | 2 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| *orris* | 132 | 0 | 0 | 5 | 4 | 1 | 1 | 3 | 35 | 0 | 0 | 0 | 0 | 0 |
| *simulans* | 63 | 0 | 1 | 7 | 5 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *valanis* | 1 | 0 | 0 | 9 | 62 | 5 | 4 | 1 | 3 | 0 | 0 | 0 | 0 | 0 |
| *Potamyia* | | | | | | | | | | | | | | |
| *flava* | 11,759 | 1 | 0 | 19 | 1,030 | 169 | 441 | 209 | 537 | 0 | 3 | 1 | 11 | 0 |
| Hydroptilidae | | | | | | | | | | | | | | |
| *Agraylea* | | | | | | | | | | | | | | |
| *multipunctata* | 0 | 14 | 17 | 24 | 0 | 3 | 0 | 2 | 0 | 3 | 8 | 248 | 49 | 3 |
| *Hydroptila* | | | | | | | | | | | | | | |
| *ajax* | 0 | 0 | 1 | 66 | 6 | 7 | 2 | 3 | 1 | 5 | 2 | 6 | 24 | 2 |
| *albicornis* | 0 | 0 | 0 | 3 | 1 | 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *amoena* | 1 | 0 | 0 | 27 | 2 | 1 | 608 | 0 | 1 | 1 | 1 | 36 | 1 | 0 |
| *angusta* | 0 | 0 | 0 | 0 | 1 | 5 | 2 | 0 | 1 | 0 | 0 | 2 | 0 | 0 |
| *armata* | 3 | 0 | 0 | 1 | 24 | 10 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *consimilis* | 8 | 0 | 0 | 95 | 10 | 31 | 29 | 9 | 0 | 2 | 0 | 6 | 5 | 4 |
| *hamata* | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 9 | 2 | 0 |
| *jackmanni* | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *perdita* | 12 | 0 | 0 | 0 | 6 | 13 | 3 | 14 | 1 | 0 | 0 | 4 | 3 | 1 |
| *spatulata* | 0 | 1 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *virgata* | 0 | 1 | 0 | 0 | 0 | 5 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *waubesiana* | 2 | 1 | 5 | 37 | 0 | 1 | 3 | 1 | 0 | 3 | 0 | 41 | 9 | 2 |

TABLE 2 (continued)

| | Fens | | | | | | | Bogs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Taxon | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| *Ochrotrichia* | | | | | | | | | | | | | | |
| *tarsalis* | 2 | 0 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Orthotrichia* | | | | | | | | | | | | | | |
| *aeqerfasciella* | 0 | 32 | 21 | 4 | 80 | 11 | 7 | 27 | 522 | 4 | 12 | 210 | 38 | 104 |
| *cristata* | 3 | 0 | 10 | 11 | 3 | 11 | 2 | 5 | 2 | 0 | 1 | 10 | 0 | 14 |
| *Oxyethira* | | | | | | | | | | | | | | |
| *forcipata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 62 | 0 | 0 |
| *pallida* | 8 | 7 | 5 | 183 | 95 | 21 | 23 | 10 | 7 | 2 | 16 | 27 | 60 | 48 |
| Leptoceridae | | | | | | | | | | | | | | |
| *Ceraclea* | | | | | | | | | | | | | | |
| *alagma* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 0 | 0 |
| *cancellata* | 23 | 0 | 0 | 0 | 1 | 0 | 3 | 4 | 2 | 0 | 0 | 15 | 0 | 1 |
| *tarsipunctata* | 0 | 0 | 1 | 11 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 20 | 0 | 0 |
| *transversa* | 0 | 0 | 0 | 281 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Leptocerus* | | | | | | | | | | | | | | |
| *americanus* | 0 | 96 | 22 | 46 | 1 | 38 | 5 | 6 | 1 | 22 | 40 | 1,125 | 17 | 168 |
| *Nectopsyche* | | | | | | | | | | | | | | |
| *albida* | 2 | 0 | 0 | 8 | 6 | 27 | 25 | 1 | 5 | 0 | 0 | 4 | 0 | 11 |
| *Oecetis* | | | | | | | | | | | | | | |
| *cinerascens* | 0 | 4 | 3 | 10 | 232 | 12 | 2 | 6 | 79 | 6 | 1 | 82 | 5 | 10 |
| *ditissa* | 2 | 0 | 1 | 1 | 17 | 8 | 0 | 1 | 2 | 1 | 0 | 2 | 6 | 24 |
| *inconspicua* | 25 | 3 | 16 | 176 | 80 | 129 | 33 | 51 | 95 | 20 | 30 | 169 | 65 | 950 |
| *nocturna* | 7 | 6 | 1 | 3 | 6 | 0 | 0 | 2 | 4 | 0 | 0 | 16 | 0 | 8 |
| *ochraceae* | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 1 | 12 | 0 | 0 | 0 | 1 | 0 |
| *Triaenodes* | | | | | | | | | | | | | | |
| *abus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 29 | 0 | 5 |
| *marginatus* | 1 | 0 | 7 | 65 | 0 | 56 | 40 | 2 | 0 | 3 | 0 | 9 | 1 | 3 |
| *tardus* | 35 | 3 | 8 | 17 | 6 | 338 | 3 | 22 | 0 | 35 | 19 | 149 | 19 | 15 |
| Limnephilidae | | | | | | | | | | | | | | |
| *Anabolia* | | | | | | | | | | | | | | |
| *consocius* | 0 | 1 | 1 | 5 | 0 | 11 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 0 |
| *Ironoquia* | | | | | | | | | | | | | | |
| *punctatissima* | 0 | 3 | 1 | 8 | 1 | 4 | 0 | 0 | 0 | 12 | 0 | 0 | 2 | 0 |
| *Limnephilus* | | | | | | | | | | | | | | |
| *indivisus* | 0 | 0 | 33 | 4 | 0 | 4 | 0 | 3 | 0 | 42 | 0 | 0 | 3 | 0 |
| *moestus* | 0 | 25 | 10 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 157 | 0 | 0 | 0 |
| *submonilifer* | 0 | 4 | 5 | 1 | 1 | 10 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| *Platycentropus* | | | | | | | | | | | | | | |
| *radiatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 11 | 4 | 12 |
| *Pycnopsyche* | | | | | | | | | | | | | | |
| *guttifer* | 0 | 6 | 0 | 31 | 0 | 6 | 16 | 0 | 0 | 4 | 0 | 0 | 0 | 33 |
| *lepida* | 0 | 4 | 1 | 1 | 0 | 3 | 6 | 0 | 0 | 4 | 0 | 0 | 0 | 5 |
| *luculenta* | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *scabripennis* | 12 | 2 | 11 | 13 | 4 | 15 | 31 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Molannidae | | | | | | | | | | | | | | |
| *Molanna* | | | | | | | | | | | | | | |
| *blenda* | 0 | 1 | 0 | 3 | 0 | 4 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Philopotamidae | | | | | | | | | | | | | | |
| *Chimarra* | | | | | | | | | | | | | | |
| *aterrima* | 2 | 0 | 0 | 13 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *obscura* | 10 | 7 | 1 | 118 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |

TABLE 2 (continued)

| Taxon | Fens | | | | | | | Bogs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Phryganeidae | | | | | | | | | | | | | | |
| *Agrypnia* | | | | | | | | | | | | | | |
| *straminea* | 0 | 0 | 2 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| *vestita* | 3 | 3 | 28 | 8 | 4 | 8 | 0 | 4 | 0 | 49 | 0 | 3 | 0 | 1 |
| *Banksiola* | | | | | | | | | | | | | | |
| *crotchi* | 0 | 0 | 1 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 27 | 1 | 52 |
| *dossuaria* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 5 | 0 | 7 |
| *Phryganea* | | | | | | | | | | | | | | |
| *sayi* | 1 | 1 | 1 | 3 | 7 | 52 | 1 | 12 | 0 | 2 | 3 | 15 | 0 | 14 |
| *Ptilostomis* | | | | | | | | | | | | | | |
| *ocellifera* | 0 | 0 | 5 | 2 | 1 | 3 | 0 | 0 | 0 | 1 | 0 | 1 | 8 | 1 |
| Polycentropodidae | | | | | | | | | | | | | | |
| *Cyrnellus* | | | | | | | | | | | | | | |
| *marginalis* | 1 | 0 | 0 | 0 | 67 | 8 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Nyctiophylax* | | | | | | | | | | | | | | |
| *affinis* | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 6 |
| *sp.* | 2 | 0 | 0 | 0 | 30 | 2 | 1 | 29 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Polycentropus* | | | | | | | | | | | | | | |
| *cinereus* | 0 | 0 | 9 | 1 | 2 | 7 | 4 | 2 | 0 | 0 | 0 | 7 | 1 | 0 |
| *interruptus* | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 58 | 0 | 0 |
| *remotus* | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 41 | 0 | 5 |
| Psychomyiidae | | | | | | | | | | | | | | |
| *Lype* | | | | | | | | | | | | | | |
| *diversa* | 0 | 0 | 9 | 49 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 10 |

*Ochrotrichia confusa* (Morton), *Oxyethira dualis* Morton, *Oxyethira novasota* Ross, *Polycentropus maculatus* Banks, *Pycnopsyche aglona* Ross, and *Pycnopsyche subfasciata* (Say).

Taxa represented by fewer than 10 specimens and present at fewer than four sites were Glossosomatidae-*Glossosoma intermedium* (Klapalek), *G. nigrior* Banks, *Protoptila maculata* (Hagen); Helicopsychidae-*Helicopsyche borealis* Hagen; Hydropsychidae-*Ceratopsyche bifida* Banks, *C. recurvata* Banks, *C. walkeri* Betten and Mosely, *Cheumatopsyche gracilis* (Banks), *C. pasella* Ross, *C. speciosa* (Banks), *Diplectrona modesta* Banks, *Hydropsyche cuanis* Ross, *H. depravata* Hagen, *H. placoda* Ross, *H. scalaris* Hagen, *Macrostemum zebratum* (Hagen); Hydroptilidae-*Hydroptila vala* Ross, *Ithytrichia clavata* Morton, *Ochrotrichia arva* (Ross), *O. confusa* (Morton), *O. eliaga* (Ross), *Oxyethira dualis* Morton, *O. novasota* Ross; Lepidostomatidae-*Lepidostoma costale* (Banks), *L. griseum* (Banks); Leptoceridae-*Ceraclea diluta* (Hagen), *C. resurgens* (Walker), *Nectopsyche candida* (Hagen), *N. diarina* Ross, *N. exquisita* (Walker), *N. pavida* (Hagen), *Oecetis immobilis* (Hagen), *O. osteni* Milne, *O. flavescens* Banks, *Triaenodes ignita* (Walker), *T. injustus* (Hagen); Limnephilidae-*Goera calcarata* Banks, *Ironoquia parvula* (Banks), *Limnephilus hyalinus* Hagen, *L. ornatus* Banks, *L. rhombicus* (L.), *Neophylax concinnus* McLachlan, *N. fuscus* Banks, *Pycnopsyche aglona* Ross, *P. divergens* (Walker), *P. subfasciata* (Say); Phrygeneidae-*Ptilostomis postica* (Walker), *P. semifasciata* (Say); Polycentropodidae-*Cerotina ohio* Ross, *Neureclipsis crepuscularis* (Walker), *Nyctiophylax moestus* Banks, *Phylocentropus lucidus* (Hagen), *Polycentropus carolinensis* Banks, *P. confusus* Hagen, *P. crassicornis* Walker, *P. maculata* Banks, *P. pentus* Ross; Psychomyiidae-*Psychomyia flavida* Hagen; and Rhyacophilidae-*Rhyacophila fenestra* Ross, *R. ledra* Ross.

Nearly 99% of all adult caddisflies were members of the Hydropsychidae, Hydroptilidae, Leptoceridae, Limnephilidae, and Phryganeidae. The family Hydropsychidae comprised 71% of the total number of individuals collected and included three of the most abundant species: *Potamyia flava* (Hagen) (38.1%), *Cheumatopsyche pettiti* (Banks) (16.1%), and *C. campyla* Ross (4.7%).

The families Leptoceridae and Hydroptilidae comprised 14.7 and 9.5% of the total collection, respectively. The leptocerids, *Oecetis inconspicua* (Walker) and *Leptocerus americanus* (Banks), were among the five most abundant species at all sites except for Betsch Fen, Liberty Fen, and Prairie Road Fen. Species of Hydroptilidae were most abundant at Brown's Lake Bog, Cranberry Island Lake Bog, Frame Lake Fen, Jackson Fen, Kiser Lake Fen, Lone Larch Bog, Prairie Road Fen, and Triangle Lake Bog (Table 2).

The Limnephilidae and Phryganeidae comprised only 1.7 and 1.0%, respectively, of the total collection but included the five most abundant species at Eagle Creek Bog, Frame Lake Fen, Gott Fen, Kent Bog, Lake Kelso Bog, Lone Larch Bog, and Triangle Lake Bog. The five most abundant genera (*Potamyia, Cheumatopsyche, Ceratopsyche, Oecetis,* and *Hydropsyche*) accounted for 77.6% of the entire collection. Table 3 lists values of Brillouins' diversity index ($H$) and evenness ($J$) (Usis and MacLean 1986) for all sites.

TABLE 3
*Number of collections (C), families (F), genera (G), species (S), individuals (N), Brillouin's diversity index (H), maximum diversity (Hmax), and evenness (J) for 123 light trap collections from 14 Ohio remnant bog and fen wetlands.*

| Site | C | F | G | S | N | H | Hmax | J |
|---|---|---|---|---|---|---|---|---|
| Betsch Fen | 8 | 9 | 20 | 38 | 13,888 | 0.279 | 1.585 | 0.177 |
| Brown's Lake Bog | 8 | 8 | 24 | 47 | 541 | 1.070 | 1.572 | 0.681 |
| Cranberry Bog | 8 | 3 | 9 | 25 | 1,325 | 0.611 | 1.396 | 0.438 |
| Eagle Creek Bog | 8 | 10 | 26 | 43 | 292 | 1.177 | 1.483 | 0.794 |
| Frame Lake Fen | 10 | 8 | 23 | 36 | 260 | 1.005 | 1.441 | 0.697 |
| Gott Fen | 10 | 7 | 21 | 38 | 349 | 1.293 | 1.502 | 0.861 |
| Jackson Fen | 11 | 10 | 30 | 69 | 7,952 | 0.624 | 1.826 | 0.342 |
| Kent Bog | 8 | 6 | 17 | 30 | 382 | 0.895 | 1.391 | 0.644 |
| Kiser Lake Fen | 8 | 8 | 23 | 52 | 1,910 | 0.838 | 1.714 | 0.489 |
| Lake Kelso Bog | 6 | 7 | 23 | 55 | 2,555 | 0.983 | 1.718 | 0.572 |
| Liberty Fen | 11 | 12 | 31 | 82 | 3,572 | 1.171 | 1.881 | 0.622 |
| Lone Larch Bog | 8 | 6 | 21 | 38 | 381 | 1.146 | 1.495 | 0.767 |
| Prairie Road Fen | 9 | 8 | 22 | 63 | 2,001 | 1.068 | 1.792 | 0.596 |
| Triangle Lake Bog | 10 | 8 | 24 | 47 | 1,653 | 0.788 | 1.639 | 0.481 |

The results of a detrended correspondence analysis (Gauch and Whittaker 1972) of these sites based on the 100 most abundant Trichoptera species is shown in Figure 2 as a two-dimensional ordination. Correlation analysis revealed significant associations of axis 1 scores with latitude ($r = -0.872$, $P < 0.001$), longitude ($r = 0.757$, $P < 0.001$), the number of caddisfly adults ($r = 0.504$, $P < 0.032$), and species diversity ($r = -0.575$, $P < 0.015$). No correlations with axis 2 scores or pH and conductivity (Table 4) were significant.

## DISCUSSION

Because of differences in the number of collections and the non-random sampling characteristics of light traps, the ordination of Trichoptera communities should be interpreted cautiously. Even though the area sampled by light traps was generally unknown, light trap collections were representative of the wetland Trichoptera fauna of different areas of the state.

The significant correlations of latitude, longitude, and species diversity with the ordination axis scores suggest that differences in the caddisfly fauna, for at least some taxa, exist between northeastern and southwestern Ohio wetlands. Correlation of Axis 1 scores

TABLE 4
*pH and conductivity μ mhos; standardized 25°C values for 14 Ohio remnant bog and fen wetlands.*

| | pH | | Conductivity | |
|---|---|---|---|---|
| Site | Max | Min | Max | Min |
| Betsch Fen | 7.4 | 7.0 | 500 | 475 |
| Brown's Lake Bog | 5.2 | 4.0 | 35 | 15 |
| Cranberry Bog | — | — | 95 | 40 |
| Eagle Creek Bog | 5.1 | 5.0 | 100 | 65 |
| Frame Lake Fen | 7.6 | 7.4 | 640 | 450 |
| Gott Fen | 7.5 | 7.0 | — | — |
| Jackson Fen | 7.6 | 7.2 | 810 | 730 |
| Kent Bog | 3.5 | 3.2 | 195 | 75 |
| Kiser Lake Fen | 7.7 | 7.5 | 440 | 425 |
| Lake Kelso Bog | 7.6 | 7.2 | 92 | 92 |
| Liberty Fen | 7.7 | 7.2 | 735 | 620 |
| Lone Larch Bog | 6.6 | 6.3 | 240 | 170 |
| Prairie Road Fen | 7.6 | 6.8 | 765 | 725 |
| Triangle Lake Bog | 4.9 | 3.6 | 88 | 88 |

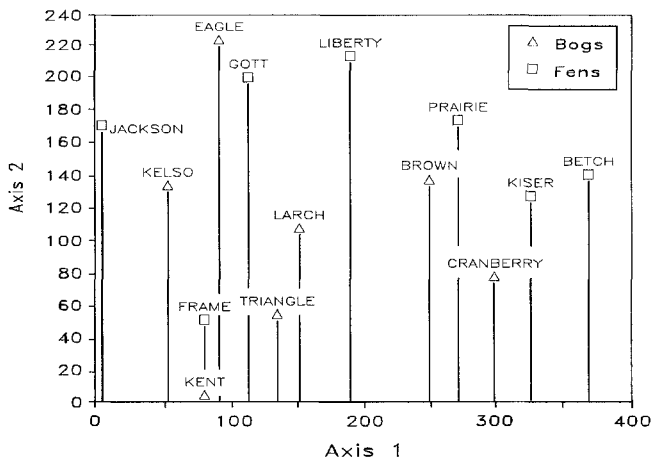


FIGURE 2. Two-dimensional ordination based on a detrended correspondence analysis of 100 species of Trichoptera collected from 14 remnant Ohio bogs and fens in 1984 and 1985.

with species richness and abundance revealed a highly significant association for only the Limnephilidae ($r = -0.637$, $P < 0.007$). This negative correlation supports the hypothesis that species of Limnephilidae are numerous in northern Ohio bogs and fens (MacLean and MacLean 1984, Usis and MacLean 1986), but rare or absent in southern Ohio wetlands.

The results also suggest that the numerical abundance of wetland Trichoptera species increases and species diversity decreases from northeastern to southwestern Ohio. Except for Jackson Fen and Triangle Lake Bog, southern and western Ohio wetlands supported the largest caddisfly populations (Table 3). Although species diversity was generally higher at northeastern sites, the largest number of families, genera, and species was recorded from tiny Liberty Fen in western Ohio (Logan County).

This study demonstrated that a large and diverse caddisfly fauna is present in most Ohio wetlands. Elimination of rare and uncommon species still leaves 75 species of Trichoptera that were collected at these sites. The families Leptoceridae, Limnephilidae, and Phrygeneidae include many genera and species of caddisflies that inhabit lentic environments (Wiggins 1977, 1984) and which were well represented in most of these wetlands. Genera of Leptoceridae that were common at

most sites were *Ceraclea, Leptocerus, Nectopsyche, Oecetis,* and *Triaenodes.* The family Limnephilidae was well represented by a large number of lentic species in the genera *Anabolia, Ironoguia, Limnephilus, Platycentropus,* and *Pycnopsyche;* the family Phryganeidae was represented by species from the genera *Agrypnia, Banksiola, Phryganea,* and *Ptilostomis.*

Wetlands are often a mosaic of aquatic habitats that provide suitable conditions for a number of caddisfly genera that inhabit lotic environments (MacLean and MacLean 1984, Usis and MacLean 1986, Wiggins 1984). Since most genera of Hydropsychidae, Hydroptilidae, Philopotamidae, and Polycentropodidae inhabit streams, springs, and seeps (Wiggins 1984), the large number of species of *Ceratopsyche, Cheumatopsyche, Chimarra, Hydropsyche, Hydroptila, Ochrotrichia,* and *Polycentropus* suggests that many wetlands provided a variety of suitable lotic habitats. The large populations of *Potamyia flava* (Hagen) at Betsch Fen, Kiser Lake Fen, Prairie Road Fen, Brown's Lake Bog, and Cranberry Island Lake Bog may have inhabited slow-moving streams that flowed into or out of these wetlands. Even though many widespread species of Trichoptera were present in both bogs and fens, the larger caddisfly populations of fens suggests a wider range of aquatic habitats and possibly less severe environmental conditions than those found in bogs.

Because of the dispersal powers of adult caddisflies and larval habitat requirements, some species may not have been inhabitants of these wetlands. For example, members of the Glossosomatidae (*Glossosoma* spp. and *Protoptila* spp.) and Rhyacophilidae are found in small, spring-fed brooks and erosional areas of rivers (Ross 1944). Although the results of this study document the occurrence of typically lotic taxa in wetlands, life history and dispersal studies and the use of emergence traps will be necessary to determine whether or not such species are permanent residents of wetlands.

Preservation of these remnant Ohio wetlands has conserved not only many plant species that are rare or endangered in Ohio, but also a large and diverse Trichoptera fauna. Caddisfly larvae function as collectors, scrapers, shredders, and predators and are important in the transfer of energy in aquatic ecosystems. In addition, caddisflies are often indicators of environmental quality. Changes in the caddisfly fauna may indicate changes in water chemistry owing to industrial or agricultural pollution, urbanization, or other human activities. Threats to the wetlands of Ohio include increased human use, drainage of adjacent land for agricultural purposes, development of surrounding urban areas, and contamination of surface runoff by organic and heavy metal pollutants. Preserves that are potentially threatened by one or more of these activities are Brown's Lake Bog, Cranberry Island Bog, Frame Lake Fen, Jackson Fen, Kent Bog, Kiser Lake Fen, and Liberty Fen.

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